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Development of Geospace Environment Simulator (GES)

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In exploration and utilization of the geospace environment, it is very important to understand the interactions between spacecraft/structures and space plasma environment as well as the natural phenomena occurring in space plasma. In order to evaluate the spacecraft-plasma interactions quantitatively to contribute to the progress of space utilization and space technology, we aim to develop a proto model of "Geospace Environment Simulator (GES)" by making the most use of the conventional full-particle, hybrid and MHD plasma simulations. The concept of GES is shown in Figure 1. The GES can be regarded as a numerical chamber in which we can virtually perform space experiments and analyze the temporal and spatial evolution of spacecraft-plasma interactions. The GES will be able to provide fundamental data regarding various engineering aspects such as the electrostatic charging and electromagnetic interference of spacecraft immersed in space plasmas, which will be useful and important information in determining designs and detailed specifications of spacecraft and space systems.

In our laboratory, we are particularly interested in the plasma kinetics and its effects on the space environment. Therefore we hire full particle-in-cell (PIC) method in the computer experiments and developed a skeleton 3D domain-decomposition EM-PIC code called NuSpace which has been well tuned for the Earth simulator. Prior to the simulations we improved the efficiency of parallelization of NuSpace. We successfully achieved 99.75% of the efficiency of parallelization.

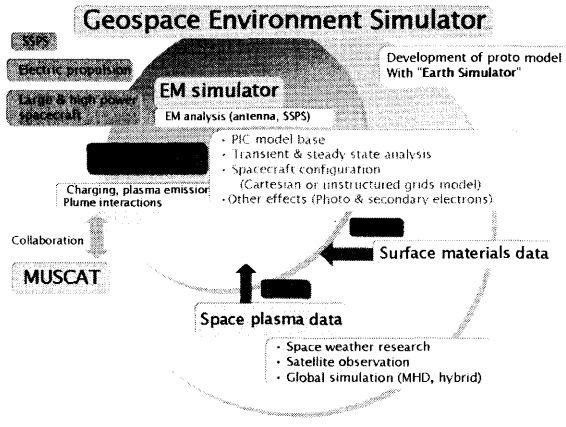

Figure 1: Concept of GES

As a test model, we focus on the situation where heavy ion beam is emitted in the magnetosphere from an ion propulsion engine used for the future orbit-transfer of large space structure such as SSPS. For the charge neutralization, thermal electrons are also emitted from the beam source. A snapshot showing the ion and electron dynamics as well as the potential profile in a plane is displayed in Figure 2. It is found that the electrons in small yellow accompanying with the ion injection are modulated by the local magnetic field and cannot perfectly neutralize the ion beam. This is also shown in red color in the potential contour map. We have working on the further analysis on field perturbation and its effect on the spacecraft environment.

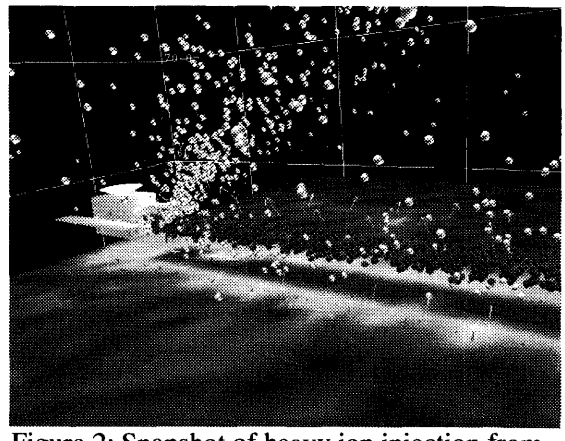

Figure 2: Snapshot of heavy ion injection from spacecraft into space plasma

REFERENCES

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